TWR-17540



Flight Set 360L007 (STS-33R) Field Joint Protection System, Thermal Protection System, and Systems Tunnel Components Final Report-Volume VII

September 1990

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SPACE OPERATIONS

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TWR-17546 Vol VII

Flight Set 360L007 (STS-33R)
Field Joint Protection System,
Thermal Protection System, and
Systems Tunnel Components
Final Report
Volume VII

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ABSTRACT

This report documents the performance of the thermal protection system, field joint protection system, and systems tunnel components of flight set 360L007 as evaluated by postflight hardware inspection.

The condition of both motors was similar to previous flights. Four aft edge strikes were noted on the ground environment instrumentation thermal protection system. The hits all left a clean substrate, indicating that the damage was caused by nozzle severance debris and/or water impact. No National Space Transportation System debris criteria for missing thermal protection system were violated.

Two problem reports were written against the field joint protection system. The first concerned two cracks in the K5NA closeout over the trunnion/vent valve location on the left-hand aft field joint. A similar condition was observed on Flight 5 (360H005B). The second problem report referred to a number of small surface cracks between two impact marks on the left-hand forward field joint. Neither area exhibited loose material or any abnormal heat effects, and they have no impact on flight safety.



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ACRONYMS

deg	degree
FJPS	field joint protection system
ft	feet
GEI	ground environment instrumentation
hr	hour
in	inch
IPR	interim problem report
JPS	joint protection system
KSC	Kennedy Space Center
L	launch
LCC	launch commit criteria
LH	left hand
NSTS	National Space Transportation System
PEEL	Postflight Engineering Evaluation Limit
RH	right hand
RSRM	redesigned solid rocket motor
SRB	solid rocket booster
STS	Space Transportation System
TPS	thermal protection system
$v \ \dots \dots$	volt
°F	degrees Fahrenheit



INTRODUCTION

STS-33R was launched from Kennedy Space Center (KSC) on 22 Nov 1989. Two redesigned solid rocket motors (RSRM) were used and were designated 360L007A and 360L007B. The three field joints on each motor (total of six field joints) were protected by the field joint protection system (FJPS) (Figure 1). The FJPS is used to keep the field joint O-rings above the minimum launch commit criteria (LCC) temperature during the launch countdown, to keep rain water from entering the field joint, and to protect the joint components from aerodynamic heating during flight. The igniter-to-case joint on each RSRM was fitted with an igniter heater to keep the igniter seals above minimum LCC temperature requirements during launch countdown (Figure 2).

The ground environment instrumentation (GEI) and heater power cables are protected by the thermal protection system (TPS). The purpose of the TPS is to protect the GEI and heater systems from aeroheating during flight.

After solid rocket booster (SRB) separation and splashdown, the SRBs were recovered and towed to KSC's Hangar AF for postflight inspection and disassembly. Retrieval and tow-back were delayed 24 hr by high sea states. The FJPS, TPS, systems tunnel, and igniter heater installation inspections were performed per Postflight Engineering and Evaluation Plan TWR-50050, Vol I (Reference 1).

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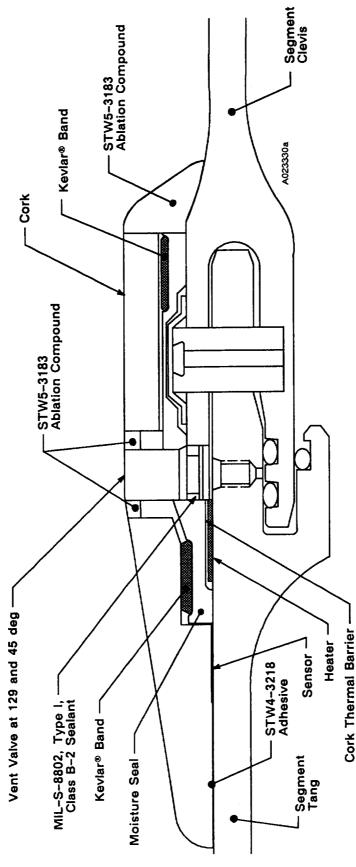
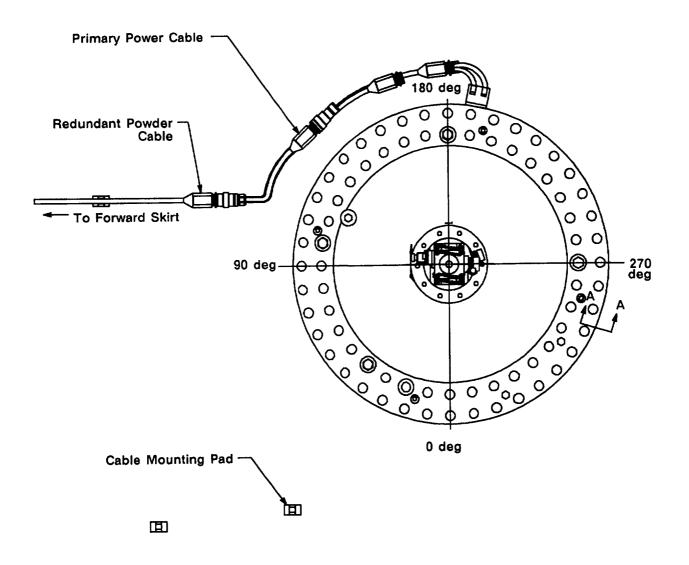


Figure 1. Field Joint Protection System

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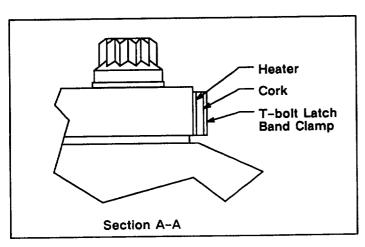


Figure 2. Igniter-to-Case Joint Heater Configuration

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OBJECTIVE

The objective of this report is to document any heater anomalies during the launch countdown and any anomalies to the FJPS, TPS, or systems tunnel components during flight and recovery operations. This report will also address all squawks or problem reports initiated during postflight evaluation.

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SUMMARY

Postflight assessment results indicate that all TPS and systems tunnel components were in very good to excellent condition (compared to previous flights) with typical flight heat effects and erosion. No squawks or problem reports were written against the TPS or systems tunnel. There were a total of four aft edge hits: three on the left-hand (LH) motor and one on the right-hand (RH) motor, with the largest missing piece of TPS cork measuring 2.5 by 2.5 by 0.5 inches. The hits all left a clean substrate, indicating that the damage was caused by nozzle severance debris and/or water impact. No Postflight Engineering Evaluation Limit (PEEL) requirements or National Space Transportation System (NSTS) debris criteria for missing TPS were violated.

Two anomalies were observed on the LH aft and LH forward field joints and were documented as Problem Reports PV-6-146407 and PV-6-146109, respectively. The anomaly in the LH aft field joint consisted of two circumferential cracks in the K5NA closeout over the trunnion/vent valve location. The cracks were about 2 in. long and did not exhibit loose material or any abnormal heat effects. The LH forward field joint had two small impact marks on the forward edge and a series of small surface cracks in between. These also showed no abnormal heat effects.



CONCLUSIONS/ RECOMMENDATIONS

The joint protection system (JPS) heaters performed as expected and maintained the field joint temperatures within the LCC required range during launch countdown. Postflight inspection verified that the TPS, FJPS, and systems tunnel all performed as designed, with typical flight heat effects and erosion. The two anomalies reported on the FJPS did not exhibit loose material or any abnormal heat effects and had no impact on flight safety or schedule.



DISCUSSION

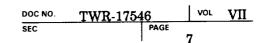
5.1 PREFLIGHT HEATER CONTROL SYSTEM AND PERFORMANCE

The field joint heaters and igniter-to-case joint heaters performed nominally during the launch countdown. The igniter heaters were activated between L - 24 hr and L - 6 hr 20 minutes, and maintained the joints within the LCC temperature limits of 90° to 108°F at all times. However, the temperature control band was changed from 95° ±5°F to 95° ±1°F, resulting in more frequent cycling and better heater control.

The field joint heaters were activated between L - 11 hr 20 minutes and L - 1 minute, and maintained an acceptable 17°F sensor temperature range from 90° to 107°F during the LCC timeframe. Prior to launch, an LCC contingency was created to lower the minimum redline temperature at any field joint from 85° to 69°F in the event of a complete heater failure. An interim problem report (IPR) was written against the LH aft field joint heater, which read 290 V instead of the nominal 209 V. This IPR was dispositioned when it was determined that the voltage must have been nominal since the current reading was nominal. In addition, the heater circuit breaker was not tripped, as it would have been had the voltage actually been 290 V.

5.2 POSTFLIGHT INSPECTION OF FJPS, TPS, SYSTEMS TUNNEL, AND IGNITER HEATER INSTALLATION

The condition of both motors was similar to previous flight motors, with most of the heat effects occurring on the inboard side of the aft segments. These areas experience high aerodynamic heating normal to protuberance components. They also receive the high plume radiation and base recirculation heating induced by the adjacent SRB and space shuttle main engines on the aft-facing surfaces. There was slight charring of the TPS over the GEI cabling runs in this area, typical of previous flights.





5.2.1 Field Joint Protection System

The FJPS was in good condition overall. There were no signs of ablation on any of the JPS, with only slight paint blistering on the cork cover. The paint on the K5NA closeout aft of the cork was also slightly darkened and blistered, with occasional pitting. This condition was typical of previous flights and was probably due to aerodynamic heating and the result of nozzle severance debris and water impact.

Numerous small cracks were observed on the forward edge of the LH forward FJPS cork between 240 and 260 deg (Figure 3). Impact marks were noted on each side of the affected area approximately 3 ft apart. Problem Report PV-6-146407 was written against these cracks (Appendix A). The cracks measured approximately 0.50 in. axially by less than 0.10 in. radially and were within the current material acceptance requirements. The impact marks were most likely caused by a parachute float line. A limit was added to the PEEL stating that cracks in the FJPS that meet current acceptance criteria are acceptable and should not be reported.

Two circumferential cracks were found in the K5NA closeout over the trunnion/vent valve on the LH aft field joint at approximately 30 deg (Figure 4). The cracks were parallel (about 1.25 in. apart) and measured approximately 2.0 in. wide by less than 0.10 in. deep. The K5NA around the cracks was bulged out about 0.10 in. and could be depressed approximately 0.10 in. with hand pressure. Problem Report PV-6-146109 was written against these cracks (Appendix A). This condition was noted on a previous flight (360H005), and it was determined that a vacuum (due to vent valve operation) developed under the moisture seal during descent. This caused the moisture seal to be pulled down over the pin retainer band trunnion. The resulting stress in the K5NA induced a split. Since the condition occurred after SRB separation, there is no impact on flight safety and no corrective action was taken.

A 4- by 2-in. local blister was observed on the LH center field joint at 45 deg. There was peeling of the Hypalon paint in the area and cork was eroded from the surface approximately 0.05 to 0.10 in. deep. This damage was a first-time occurrence and was probably caused by burning debris from the nozzle severance system. No squawks or problem reports were written against this condition.





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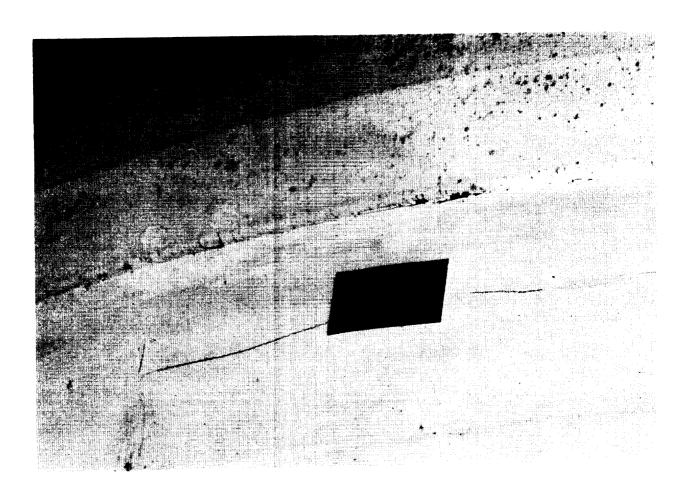


Figure 3. Impact Marks on FJPS Cork (LH forward field joint)



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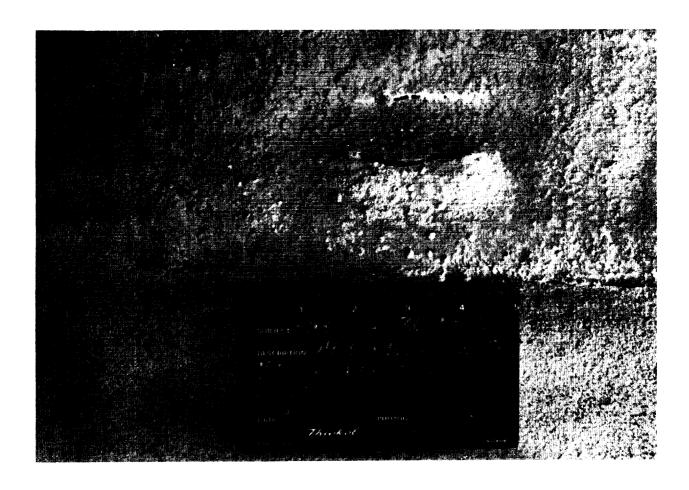


Figure 4. Splits in K5NA Ablation Compound (LH aft field joint)



5.2.2 Thermal Protection System

TPS performance was considered to be excellent during flight operation, with typical heat effects and no ablation. There were no in-flight anomalies, squawks, or problem reports written against the TPS.

There were a total of four aft edge hits: three on the LH forward center segment and one on the RH forward segment. The TPS cork pieces that were missing all left a clean substrate, indicating that the hits were caused by nozzle severance debris and/or water impact. The largest GEI cork piece missing was approximately 2.5 by 2.5 by 0.5 in., or 3.1 in.³. This piece was located at Station 691 on the RH forward segment at approximately 240 deg. No PEEL requirements or NSTS debris criteria for missing TPS were violated.

5.2.3 Systems Tunnel

The cork TPS adjacent to the systems tunnel floor plate was in excellent condition. There was very little paint blistering, and all K5NA closeouts over cables and tunnel seams were in excellent condition. No in-flight anomalies, squawks, or problem reports were written against the systems tunnel.

5.2.4 Igniter Heater and Forward Dome Power Cable Installation

Postflight inspection of the igniter heater installation and power cables revealed no anomalies. The igniter heater, cork, and band clamp were removed and inspected at Hangar AF; no anomalies were noted.



REFERENCES

- 1. TWR-50050 Vol I, Book I, Rev A, KSC Postflight Engineering Evaluation Plan (Internal and External Insulation), L. E. MacCauley and T. Morgan, 21 Nov 1989.
- TWR-17432, KSC Ten-Day Postflight Hardware Evaluation Report for 360L007,
 L. E. MacCauley and T. Morgan, 18 Dec 1989.
- 3. TWR-17546 Vol I, Flight Motor Set 360L007 (STS-33R) Final Report, D. M. Garecht, 4 Jun 1990.

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Appendix A LH Aft Field Joint Anomaly Documentation

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REVISION

Thickol CORPORATION

SPACE OPERATIONS

POSTFIRE OBSERVATION RECORD (PFOR) A-4 Field Joint External Insulation Condition

Motor No.: 36	0L007	Sid		i insulation Ci	Date	B: /1/2	6/89	
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Thickol CORPORATION SPACE OPERATIONS

Aft Segment TPS Clarification Form

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2. SRM MOTOR NUMBER 360L007A	H-7 A-2	6. REFERENCE N/A	IFA NUMBER	7. REFERENCE N/A	SPR NUMBER	
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Quality Assurance Approval

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KSC FORM 2-155 (REV. 6/84)



Appendix B LH Forward Field Joint Anomaly Documentation

DOC NO. TWR-17546 VOL VII

Thickol CORPORATION SPACE OPERATIONS

POSTFIRE OBSERVATION RECORD (PFOR) A-4

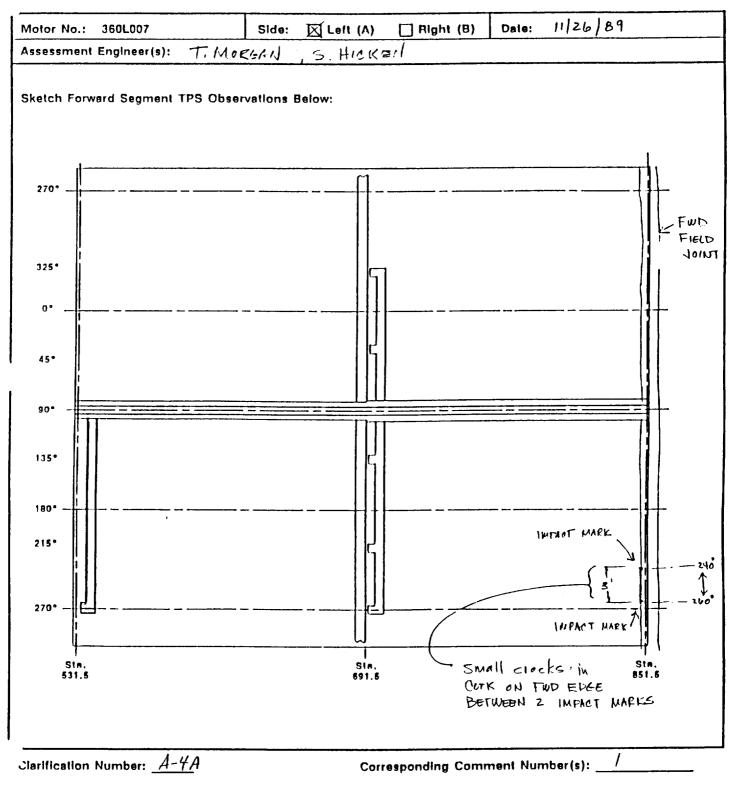
		Field	Joint Extern	al insulation (Condition			
Motor No.:	360L007	SI	de: Left (A)	Dat	te: /1/26	119	
Assessment E	ngineer(s):	T. MORGAN	, S. HICK	EN		<u> </u>		
Joint: Forwa	ard (FWD)							
B. Missing	d/Heat Affect g TPS Materi	on Observation ted Material (i al > 0.7 cu. in ation (TPSVD)	HTAFF)? n. Due To		Yes	No 	Con	nment #
Reentry D. Unbond E. Evidend Joint (' F. Missing	y/Debris/Wate ds/Cracks (Di ce of Water WATER)? g/Unbonded \	al > 0.7 cu. ir er Impact (TP EBND)? Leakage From Vent Valves (I TT Joints only.	SDM)? n Field MISSG)?					
Record the fol	lowing if any	of the above	conditions e	xist:				
Condition (Observation Code) DE BND	Starting Station Location (in.)	Ending Station Location (in.) N/A	Starting Degree Location (deg.) 240	Ending Degree Location (deg.)	Circum- ferential Width (in.) ~ 3 fT.	Axiai Length (in.) ~ · 50/A).	Radiai Depth (in.) < , 16	Volume (in.³) _ <i>N</i> /\$
Notes / Comm	ents							
SIDE	IMPACT 6F AFF	MARKS ((POSSIELE	PARACHU.		LINE) L	ON EN	
Clarification she	eet(s) attach	ed?	no	A-4A	_ yes (Provi	de clarifica	llon numb	per(s).)
REVISION					DOC NO. T	WR-17546	VOL	VII

SEC

Thickol CORPORATION SPACE OPERATIONS

REVISION _____

Forward Segment TPS Clarification Form



TWR-17546

PAGE

DOC NO.

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VOL VII

		Pago
SRR/SRM POSTFLIGHT	HARDWARE ASSESSMENT	1 01 1
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OPEN ASSESSMENT ON DOCK	T (II	0. QUANTIT
5. WORK UNIT CODE STRANT NAME INT PROTECT	7. PART NUMBER 8. BERIAL NUMBER	1
INSULATION SYSTEM	DA 1076 803-01	
11. MILAIPH 12. STS KUMBER 13. REPORT	LICKEN / THIOKOL, 26NOV 87	/12:00
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16. PHOTOGRAPHIO NUMBER 114477 - 5	SBI KMTI OTHER	
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CONTRACTOR DOARD MEMBER/DATE		

POSTFIRE ANOMALY RECORD (PFAR)

1. PFAR NUMBER 360L007A-05	3. INSPECTION LOCATION KSC X T-24/T-97	4. REFERENCE SQUAWK NUMBER 33-031	5. REFERENCE PR NUMBER PV6-146407
2. COMPONENT PROGRAM TEAM JPS	H-7 A-2	6. REFERENCE IFA NUMBER N/A	7. REFERENCE SPR NUMBER N/A
8. TITLE IMPACT MARKS/SURFACE CRACKS	ON FORWARD FIELD JOINT FJPS		
9. CLASSIFICATION OBSERVATION	MINOR ANOMALY X	MAJOR ANOMALY	CRITICAL ANOMALY
10. JUSTIFICATION OF CLASSIFITH This is a first-time occurre	CATION ence but this condition impos	es no impact on flight safety or	schedule.
11. PART NUMBER 1U76803-01		PART DESCRIPTION LD JOINT PROTECTION SYSTEM	
14. REPORTED BY (NAME / ORGAN S. V. HICKEN / THERMAL	IZATION / OBSERVATION DATE) INSULATION DESIGN ENGINEERIN		
15. RESPONSIBLE PROGRAM MANAI G. L. STEPHENS / JPS PROG	GER (NAME / ORGANIZATION) GRAM MANAGEMENT	16. RESPONSIBLE POSTFIRE ENG G. S. NIELSON / POSTFIR	SINEER (NAME / ORGANIZATION) RE HARDWARE ENGINEERING
17. RESPONSIBLE INTEGRATION R. S. JENSEN / SYSTEMS	ENGINEER (NAME / ORGANIZATION INTEGRATION ENGINEERING	1) 18. RESPONSIBLE ACTIONEE (NA C. L. PROKOP / STAGE H	AME / ORGANIZATION) HARDWARE DESIGN
19. DESCRIPTION (ATTACH PFOR Numerous small cracks were	s, FIGURES, PHOTOGRAPHS, ETC.) of the forward field joint FJPS fected area approximately 3 feet	cork from 240-to-260
20. HISTORY None. This is the first ti	me that cracks of this type h	nave been reported.	
21. CAUSE Cracks of this size meet th a parachute float line.	e current material acceptance	e requirements. The impact mark	s were most likely caused by
22. CORRECTIVE ACTION Add a limit to the PEEL sta should not be reported.	ting that cracks in the FJPS	that meet current acceptance cr	iteria are acceptable and
23. RESULTS TWR-50050, Vol. I, Rev. C w	ill state "Cracked cork or K	5NA with no missing material - A	cceptable".
24. REPORT RESULTS TO RPRB? YES NO X 25. RPRB MEETING DATES	26. APPROVAL THROUGH CORRU RPRB SECRETARY: /S/S. T. MUNSON SIE: /S/R. S. JENSEN	ECTIVE ACTION 27. CLOSURE DATE: RPRB SECRET 12/13/89 N/A DATE: PM: MY	ary: DATE: N/A Heghew DATE: 10 July 40
ORIGINATION: 12/13/89 CLOSURE: N/A	PM: /S/G. L. STEPHENS	DATE: // / / / / / / / / / / / / / / / / /	

REV. 2/1/90

PR CLOSURE APPROVAL

Ref. P.F.A.R. Number: 360L007A-05

Engineering Approval

Signature

W. N. Hanto

Quality Assurance Approval

200

Signature

Date

2/6/90

Date 2/13/90

N.A.S.A. Resident O.A. Approval

J. A. Lew Signature

Signature

2/13/90 Date

N.A.S.A. R.M.O. Manager Approval

Eignature Skrobissewski

/ Date

N.A.S.A. S.R.M. Chief Engineer Approval

Signature

oss for K. JONES

Date

2-20-90

	1. REPORT NUMBEP	PAGE
	NASA A USAF INTERIM PROBLEM REPORT	
	Neuronal Arromatics and Source Administration Department of the Art Farce United States of America Department of the Art Farce Department of Art Farce Department of the Art Farce Department of Art Farce Departmen	OF
	Kennedy Space Center/Vandenberg Air Force Base DISCREPANCY REPORT	0,
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